Forbes Lake Water Quality

A Report on Water Quality Monitoring Results
for Water Year 2009

Prepared for the City of Kirkland
by the King County Lake Stewardship Program

December 11, 2009

King County

Overview

In May 2006, residents at Forbes Lake began monitoring water quality through participation in the King County Lake Stewardship Program (KCLSP). Volunteer monitoring efforts continued through 2009. Physical and chemical data collected through three years of monitoring suggest that this small lake in the city of Kirkland is moderate to high in primary productivity (mesotrophic-eutrophic), with fair water quality.

Although there is no public access boat launch, there are several public parcels adjacent to the lake, and the opportunity exists for members of the public to access the lake at several points, as well as to launch small car-top boats. Residents should keep a watch on aquatic plants growing near shore to catch early infestations of Eurasian milfoil, Brazilian elodea, or other noxious weeds.

Later in this report references will be made to two common measures used to predict water quality in lakes: the Trophic State Index or TSI (Carlson 1977), and ratio of nitrogen to phosphorus (N:P). The TSI values and N:P ratios were calculated from the data collected through the volunteer monitoring program. TSI values are derived from a regression that relates values of a parameter such as total phosphorus, chlorophyll *a* or Secchi transparency to the predicted algal bio-volume, assigning a number on a scale of 0 to 100. This scale can be used to compare water quality over time and between lakes. To date not enough data has been collected at Forbes Lake to verify a trend statistically, although it appears that the lake is generally high mesotrophic to low eutrophic in algal production.

The discussion in this report focuses on the 2009 water year. Specific data used to generate the charts in this report can be downloaded from the King County Lake Stewardship data website at:

http://www.metrokc.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx.

Or can be provided in the form of excel files upon request.

Physical Parameters

Excellent precipitation and water level records were compiled for the 2009 water year. Water levels rose quickly in response to heavy or prolonged rain events during the period, which suggests that precipitation falling in the watershed flows quickly as surface water to the lake, with limited infiltration. Because the area of the watershed is large relative to the size of the lake, surface inflows from the watershed are likely to affect lake levels more than does direct precipitation to the surface of the lake. Precipitation and lake level data collected since May 2006 suggest the lake does rise with autumn rains and can remain slightly elevated through the winter and into spring. However, in 2009 the lake level remained low until January when it began to rise and then varied around a very high level through a hot and dry summer. This might be explained by blockage in the outlet, either from beaver dams or debris jams. Though is great variation in the range of lake levels through the year, the highest lake levels do not appear to persist longer than a week or two (Figure 1).

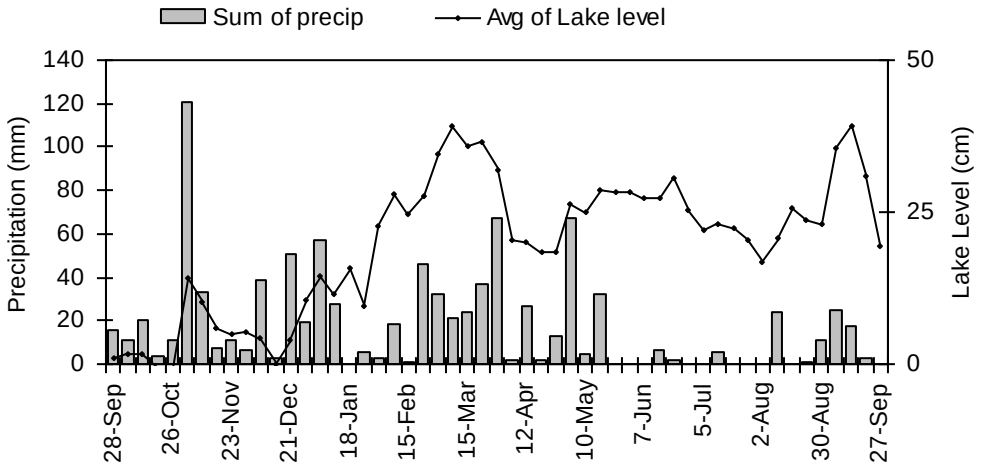

Figure 1. WY 2009 Forbes weekly Lake Level and Precipitation

Secchi transparency is a common method used to assess and compare water clarity. It is a measure of the water depth at which a black and white disk disappears from view when lowered into the water from the surface.

Volunteers collected Secchi transparency and temperature data from early May through late October during the "Level 2" monitoring season, when volunteers collect water samples for laboratory analyses. Secchi transparency from May through October ranged between 1.3 and 2.6 meters (Figure 2).

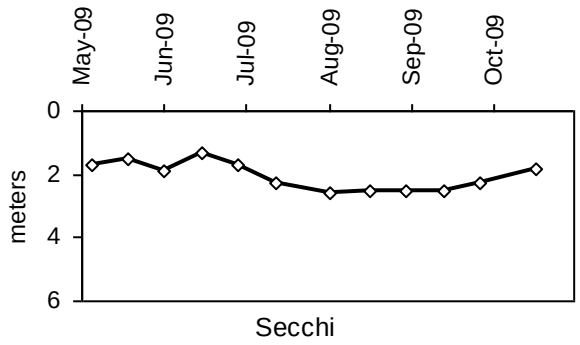

Figure 2. WY 2009 Forbes Secchi Levels

The summer average was 2.1m, which placed it in the mid range for monitored small lakes in 2009. Surface water temperatures ranged between 13.0 to 27.0 degrees Celsius with an average of 20.2 degrees Celsius. The high temperature in early August was due to a long, hot streak in the previous weeks that bumped up all lake temperatures in the Puget Sound lowlands to very high levels. The recorded maximum temperature was in the mid range of values reported among the group (Figure 3).

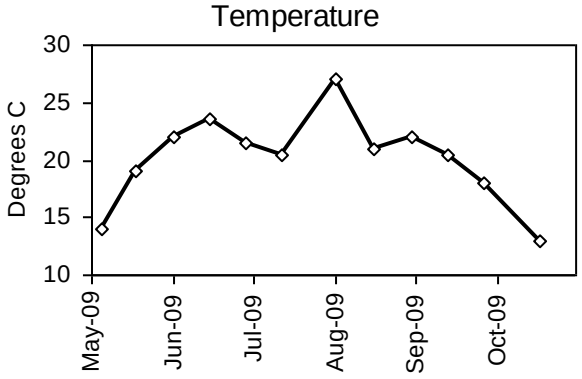

Figure 3. WY 2009 Forbes Temperature

Nutrient and Chlorophyll Analysis

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological primary productivity (from algae) is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential health and safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

During the monitoring period, the highest TN values were in the first sample of the season dropping throughout the summer and then climbing again in late August and October. TP was high in late summer, dropping in September, but climbing again in October. (Figure 4).

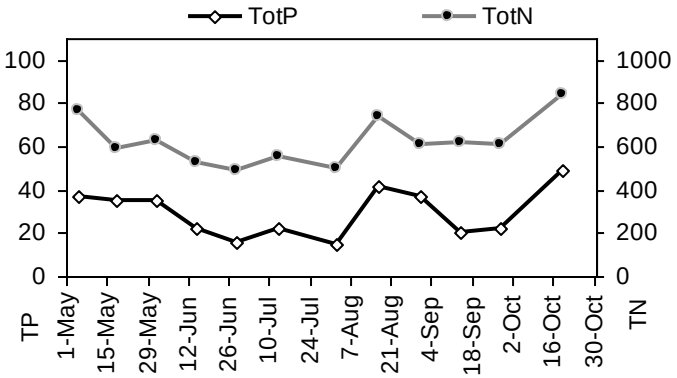

Figure 4. 2009 Forbes Lake Total Phosphorus and Total Nitrogen Concentrations

The ratio of nitrogen (N) to phosphorus (P) can be used to determine if conditions are favorable for the growth of cyanobacteria (bluegreen algae) that can impact beneficial uses of the lake. When N:P ratios are below 20, cyanobacteria can dominate the algal community due to their ability to take nitrogen from the air. Total phosphorus and total nitrogen remained in relatively constant proportion to each other through the sampling period, ranging from 16.5 to 32.6 with an average of 23.1, which suggests that there were times during the sampling period when conditions were favorable for nuisance bluegreen growth. The lower N:P ratios occurred during spring and then in fall, suggesting that if a nuisance bluegreen algae bloom were to occur, it would be during these seasons, and most likely in fall.

Chlorophyll *a* concentrations varied through the season. There was a maximum in mid May, declining in early June through mid-July, and then climbed through late summer to a smaller peak and fell back in fall. (Figure 5). Pheophytin, which is degraded chlorophyll, was generally below detection levels or only in small amounts throughout the period. The high chlorophyll a levels suggest there was an abundance of phytoplankton at the 1 meter level at some times during the sampling season.

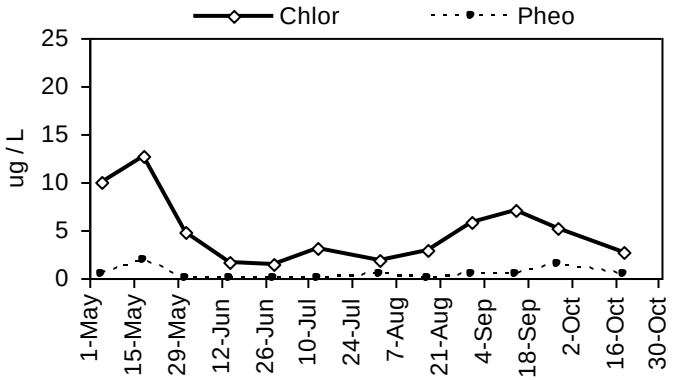

Figure 5. WY 2009 Forbes Chlorophyll *a* and Pheophytin concentrations

Profile data indicate that thermal stratification was present in late summer; however, deep water temperature data was not collected for the first profile event. Cool temperatures persisting in the deep water may indicate the influence of ground water inputs. Higher concentrations of both total and dissolved phosphorus were found in the deep water in May as well as in August, suggesting that anoxia could have triggered a release of phosphorus from the sediments. High ammonia concentrations and lack of nitrate or nitrite in the deep water also indicate hypolimnetic anoxia (Table 1).

Table 1. Forbes Lake Profile Sample Analysis Results

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NO2-3	NH3	Total P	OPO4	UV254	Total Alk
Forbes	5/18/09	1.5	1	19.0	12.8	1.8	0.590	**<MDL**	0.014	0.0350	0.0048	0.347	53.7
			4		7.2	2.2	0.827			0.0346			
			7		7.8		1.190	0.040	0.763	0.1460	0.0408		
Forbes	8/31/09	2.5	1	22.0	5.8	**<MDL**	0.607	**<MDL**	0.017	0.0367	**<MDL**	0.361	61.0
			4	15.2	11.9	2.3	0.428			0.0202			
			7	6.5	19.4	ChlorB	1.630	**<MDL**	1.490	0.2030	0.0440		

The moderate values for UV254 indicate that the water of the lake is slightly colored from organic substances, while the total alkalinity values show that the water in the lake less soft than in less developed watershed and is somewhat buffered from pH change. NOTE: In Table 1, <MDL stands for "below minimum detection level" of the analytical method.

Chlorophyll *a* profile data indicate that algae are present throughout the water column. The highest concentration of algae occurred in the seven meter sample in the August profile, which suggests that at that time the majority of the phytoplankton present in the lake were found in deeper water.

TSI Ratings

A common method of tracking water quality trends in lakes is by calculating values for the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI values predict the biological productivity of the lake based on water clarity (Secchi) and concentrations of TP and chlorophyll a. There are 3 categories of productivity: oligotrophic (low productivity, below 40 on the TSI scale); mesotrophic (moderate productivity, between 40 and 50); and eutrophic (high productivity, above 50).

The 2009 TSI indicators for Secchi and TP were very close to each other just above the threshold for the eutrophic range (Figure 6), while the TSI –Chlorophyll *a* indicator was in the lower end of the mesotrophic range. The average of all 3 TSI indicators in 2009 was slightly lower than the averages for 2006 through 2008, putting Forbes into the higher mesotrophic range. Additional years of monitoring would be necessary to determine if the trophic status of Forbes Lake is relatively stable, or following an upward or downward trend.

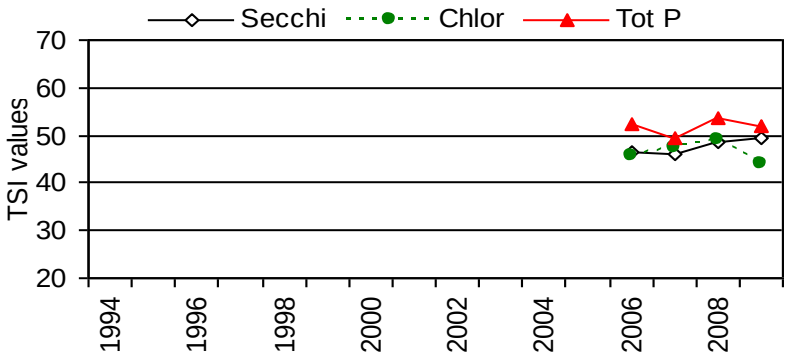

Figure 6. Forbes Lake Trophic State Indicators

Conclusions and Recommendations

Based on monitoring data, water quality in Forbes Lake was generally stable over the period measured. Low average N:P ratios could indicate conditions are favorable for nuisance bluegreen algae blooms, particularly in the spring and fall. It is recommended that continued monitoring of nutrient and chlorophyll concentrations be done to assess conditions and to look for trends. Close monitoring of algae blooms at the lake should also be done, including participation in the Washington State Department of Ecology's Toxic Algae Monitoring program to determine whether or not blooms found in the lake may occasionally produce toxins.